American Medical Association

March 11, 1996

Remarks Prepared for Delivery By:

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National Aeronautics and Space Administration

I. VISION

Intro:

-- Bell Atlantic technician: "Space is about my children's future." --

- Galileo
- CNN
- Geoff Marcy
- Hubble -- deep field galaxy, planet, star factory.

Things to Come:

- Just launched NEAR 2/15
- Mars Global Surveyor 11/15
- Mars Pathfinder (Mars 96) 12/5

- LMS '96
- Neurolab (with NIH) '98
- Lunar Prospector 6/98
- Cassini 10/97
- Stardust 1999
- Deep Space One Summer/1998
- Mars Global Surveyor 2 12/98
- Mars Lander 2
- Mars Penetrator
- Deep Space 2

Remote Sensing:

- Hubble 2/97
  - -- UV spectrometer
  - -- NEAR-IR imaging spectrometer
- Palomar Interferometer

- KECK 2 Fall/98
  - -- Extra-solar zodiacal light
  - -- Detect Jupiter-class planets
- Other ground telescopes
- Study Earth environment
  - -- Lewis
  - -- Clark
  - -- TRMM
  - -- Topex follow-on
  - -- EOS AM-I
  - -- EOS PM
  - -- Landsat
  - -- Sea Star
- We're opening the space frontier
- Findings strike a chord -- touch the human spirit (not only intellect).

- Touch need to explore

  -- Origins
  -- Future for children

- Don't worry day to day

  -- Why are we here?
  -- How do I relate?
  -- Where are we going?
  -- What are the possibilities?

- More than food and shelter

  -- Understand order
  -- Enriching life
  -- Better understand their God

- Drives me

  -- Pinch to see if real
  -- Privilege bestowed by President
     each day, until he decides not to.
  -- That's been known to happen

WHAT AN EXCITING TIME TO BE ALIVE

- Others had same dream

- We have the tools
- It is the dawn of a new era!

Decades ahead in our planetary exploration -- UNIFYING VISION

Understand -- Enrich -- Excite

- See planets light years away
- Analyze bodies near by
- Walk on bodies out of Earth orbit

<u>This is today's subject. I will</u>:

- Pose questions
- Tie issues together
- Explore issues
- Set goals
- Define thresholds

- Have fun

I will not:

- Announce disconnected, feel-good missions

- Thanks for consultation --

  - Harry Holloway
  - Wes Huntress
  - Sam Venneri
  - Jeff Plescia (Play sha)
  - Gene Shoemaker
  - France Cordova
  - Carl Pilcher
  - Mike Meyer
  - Charles Townes

Exploration and Search for Origins and Sustenance of Life:

Three fundamental interconnected multidisciplinary questions --

1) Where did galaxies, stars and planetary bodies come from and how did they evolve?

2) Are there other places that had an "environment," have an environment, or might have an environment hospitable to life and/or commerce?

3) Is life of any form unique to Earth?

- Not a program
- Not a discipline
- Not an agency
- Not a specific date
- But an integrated, multidisciplinary scientific, technical, cultural, economic quest

SUSTAINED PRESENCE

To attempt to answer these questions, we could:

1) Survey space to search for and analyze earliest forms of galaxy

2) Search for and analyze stars and planetary systems in process of forming

3) Search for and analyze extrasolar planetary systems in our "neighborhood"

4) Search for and analyze planetary bodies that were, are, or could be habitable and/or could have resources of economic interest

5) Search for resources and/or signs of life (including alternative forms) in our own solar system -- places we have yet to go to and "appropriately" explore

6) Attempt to determine some of the factors controlling the origin and fate of the universe, our solar system

7) Benefit people in America and on planet from richness of findings and technology utilized

- Takes full integrated capability of country, world

- Not a single-point Apollo sprint

- Answer basic questions

- Seek benefits by sustained virtual and real presence in space

- Marathon, not sprint

- Not simple sprint or rush

- Demands revolution because so hard

- Driven by cost / benefit
  (progress) (progress)

  rationale, inspiration

So everything is connected. New relationships with industry and academia.

Apollo era gone -- budget going down. 21st Century thinking in.

- NASA no longer object/program oriented.

  -- Planetary

  -- Astrophysics

  -- Life science on Shuttle

- No longer spectrum-oriented

- No longer constituent-oriented other than American people

• Shared unifying vision and Strategic Plan with:

-- Administration
-- Congress
-- Science community
-- NASA employees and contractors
-- American people

Strategic Management System

HQ strategy what, why
requests
budget

Centers how
Lead Centers

Engineering
short cycle time
low cost
technology pipeline
incremental but revolutionary progress

design, build, fly

young engineer

- We will not specify tools but ask basic questions.

  -- Send astronauts back to Moon

  -- Operate Shuttle 2025

  -- No biology in Mars landers.

  -- ISS will not have organic asset

- Peer review

Planetary Exploration Richer --

- Explain
- Multidisciplinary integrated knowledge
- As far as eye can see, and arms extend

<u>Four Phases of Planetary Exploration</u>

1) Robotic Precursors

2) Initial Human Exploration

3) Robust Human Exploration

4) Sustained Human Presence

First three have hierarchies

- Resolution (spatial, temporal, spectral, analytic)
- Adaptability of tools

- Telescopic Observations
- Flyby (Mariner II to Venus)
- Orbit (Lunar/Mariner)
- Land (Surveyor/Viking)
- Rove (ground/air)
- Bring back samples (or in situ labs)
- People on surface

  -- Apollo (enabled by Saturn and LEM technology)

  -- (Jack Schmidt -- active volcanism orange glass)

-- Cognitive ability

-- Versatility

-- Manual dexterity

-- Adaptability

Threshold determined 01--02--03

- Potential benefit/cost -- scientific, economic

Output:

Scientific benefit examples:

1) Present or past forms of life

2) How planet structured, how evolved, implications to Earth's evolution or general theory

3) Unravel bodies' climatic/environmental history, better understand climatic/environmental models, better understand Earth

Economic benefit examples:

1) Finding resources to live off the land

2) "Natural resources" of economic value

3) Environmental factors conducive to manufacture of high value products

- Maybe, just maybe -- Tom Rogers
- Hadley Rille Hilton?

<u>Input</u>

- Cost

  -- launch/cruise

  -- On body infrastructure

Rationally weigh

1) Government investment in science return or enabling space infrastructure (real potential) -- (science cost share)

2) Private investment in commerce

- not feel-good

- not space cadets
- payback in "reasonable time"

- Scientific geological field work 01 -- 02 (Landsat, aircraft--field)

  -- Unique capabilities

  -- Australia processes

  -- Not landsat or robot (perhaps deep sea)

  -- Plane/car to field

Search for life is most compelling (others just as interesting)

- Time Magazine
- Media last few weeks

intellectual/emotional

<u>Define Life Zone</u>:

- Not range of distances from Sun

-- conventional thought
-- water stable

• More encompassing -- range of multidimensional space

-- temperature
-- pressure
-- composition
-- time

in which conditions necessary for life could, does, did

• Robots have begun to define life zone:

Earth	antarctic, deep oceans, Australia
Mars	active pursuit robots -- canyons, volcanoes lake beds, comet/ asteroids, landings people -- ground water, sedimentary culture

(intellect, adaptability, manual dexterity, versatility)

• Investigate complex environments with interplay of:

-- geological processes

-- chemical processes

-- physical processes

-- biological processes

-- transport processes

Produce conditions can't always predict or imagine

Maybe Europa

-- Galileo -- this summer
-- 10 km ice/100 km ocean
-- gravitational heating
-- chondritic meteorite density

• Ocean floor like Earth's floor?

• Time creepy crawlers?

• I don't know -- keep an open mind

Venus -- maybe billions of years ago

Moon -- Lunar prospector 1998

Maybe Titan -- Cassini 1998

Maybe asteroids -- low g -- Gene Shoemaker

- Some ground truths in future

  -- Jupiter sized 35 Au

  -- more and smaller later

- Understand life here

  -- be open

  -- imaginative

- Could there be blue green balls? Blue purple balls?

  Chlorophyll -- rhodopsin
  photosynthesis

Is life the same?

- 03--04 Sustained Presence

  -- indigenous, available, usable resources of economic or scientific value

  -- economical
     - transit
     - surface infrastructure
     - break Earth tether

  Can we/will we?

II. MEDICAL CHALLENGES TO CARRYING OUT THIS VISION

In General:

- We must address a broad array of scientific, technical, and medical challenges.

- We must integrate progress in a broad range of disciplines.

- We will create systems of unprecedented complexity. Yet, these systems will be absolutely reliable -- self-diagnosing and self-repairing.

• We will need to combine operational simplicity with a remarkable level of inherent complexity.

Specific Medical Challenges:

1) Environmental Quality in Space

• Need life support systems for exploration that are significantly less massive and require only minimal resupply of consumables like water, air, and food.

• Biological and physical/chemical life support systems must be harnessed together. (Plant systems genetically selected to maximize oxygen and food production may be combined with microbial systems that can purify water. Special chemical filters may remove or regulate the microbes and remove toxins from the air. New material will be developed to prevent the formation of biofilms on surface in the spacecraft.)

2) Radiation Environment

• In space, beyond the protection of the Earth's magnetic field, we face not only gamma rays, protons and neutrons but also large plasma

particles consisting of atomic nuclei like iron -- so-called cosmic rays.

- We must learn more about the effects of space radiation, and how to protect space crews (especially from cosmic rays).

- We'll need advanced integrated spacecraft immune from cosmic rays and radiation. We'll need new types of radiation shielding materials -- may include new carbonaceous and hydrogenated organics.

- Need new medical techniques to select crews and protect them against space radiation. We may need to identify genetic markers or other indicators that will allow us to identify individuals at low risk for eventually developing cancer.

- How is the biological damage caused by radiation repaired in microgravity? Can medication prevent damage or improve and hasten repair?

3) Counteracting the Negative Effects of Low Gravity on the Human Body

- Travel in space exposes life to a gravity environment that's unique in the 4-billion-year

history of life on Earth. This presents us with remarkable opportunities for medical research in space. It also presents us with medical challenges for maintaining crew health on long journeys.

- Long exposure to microgravity influences virtually every system in the body. We will need to identify and control the negative effects of long-term space flight.

    - Bone loss
    - Muscle atrophy
    - Changes in the way drugs are absorbed and distributed in the body
    - Changes in the immune system that protect against infection

- On short flights, neurons within the neurovestibular system begin to change soon after moving outside of Earth's gravity. They adapt, developing new connections (synapses) with other nerve cells .

    - What are the implications for long-term adaptation?

    - There is evidence that the body retains these adaptations for some time after returning to Earth. Perhaps we can

harness these phenomena to encourage recovery in conditions where nerve cells in the brain or spinal cord are injured.

4) Providing Health Care

• Must be able to support the health care needs of a very remote crew.

• The communication time to Earth at the speed of light will take at least 20 to 50 minutes for long journeys. Need telemedicine and informational tools that can assist in medical decision-making while helping the medical crew retain their medical and surgical skills.

• Need totally new concepts for medical care on very long space flights: nano-technology, chemical surgery, methods for selecting and inducing resistance to illness.

5) Dealing with Psychological Factors of Long-Term Isolation in Space

Our space crews will be farther from home than anyone has ever been before. They'll be:

• away from their families and friends

- confined to a small space for long periods of time
- surrounded by an immense and hostile environment
- unable to hold a normal conversation with anyone not on their spaceship.

Challenges:

- How do we keep a crew psychologically healthy under these circumstances?

- How will the crew adapt, how will they function as a team?

- How do we prepare the crew to respond to emergencies in space?

- How do we prepare them to deal with emergencies at home?

We'll need to develop novel approaches to communications and information transfer.

6) Integrating Humans, Robots, and Computers into Efficient and Self-Sufficient Systems in Space

• **Robots** will be the human surrogate and assistant. They will see, hear, touch, smell, speak, think, learn, and perform controlled mechanical operations.

• **The human crew** may be so fully integrated with their spacecraft that the system could best be modeled as a single, living system.

We must reduce the complex information sets to understandable, narrow-band-width displays. Our crews will be totally immersed in interactive multi-sensory environments.

• **For spacecraft**, we'll need new principles that will allow for self-regulation, self-repair, and autonomous operation of critical systems elements. They'll use neural-net and micro-processor technology inspired and guided by the principles of neuroscience.

These spacecraft may use the principles discovered in immunology -- to create micromachines that can identify malfunctions then send micromachines to repair the problem.

Systems will have complex environmental inputs, stochastic processes, and nondeterministic systems. We'll need to approach the problem of design from the

molecular level up, using physics-based design tools.

Genetic algorithms will provide stable state changes in complex systems. Those processes and algorithms must be adapted into new tool sets.

III. MEDICAL BENEFITS ON EARTH OF PURSUING NASA'S VISION IN SPACE

What we do in space could have tremendous application on Earth. I'm just going to mention a few possibilities and actual benefits in the areas of:

- Health Care
- Biomedical Research
- Human-Machine Interface, and
- Advanced Life Support

Health Care

Future possibilities --

- Imagine the implications of developing systems and technologies to provide health-care across distances of millions of miles!

-- Chemical surgery techniques that can heal without scalpels or incisions

-- Micro-machines in the bodies of our crews to monitor or treat problems

-- Artificial antibodies to deliver "nano-machines" directly to the site of a problem

• What could screening techniques for astronauts mean on Earth? Could our multi-disciplinary approach to this lead to early detection and prevention of disease?

Examples of current benefits --

• Already, "telemedicine"--pioneered in the Apollo days-- promises to vastly improve medical care. It's been used during natural disasters and to serve the needs of remote populations in the southwestern United States.

Internet technology promises to greatly expand this capability.

• Tiny sensors that measure the pH of body fluids were developed for use in space research. Now, they're being modified by pediatric surgeons from the University of California at San

Francisco and NASA biomedical engineers to monitor the post-operative health of unborn patients who were operated on to correct congenital anomalies, such as the lack of a diaphragm.

New technology should lead to nano-sensors of molecular or perhaps atomic dimensions that can be safely placed in an astronaut or patient to monitor a specific organ function.

Biomedical Research

Future possibilities --

Is there a fundamental advance in our understanding of the aging processes waiting for us in space?

Healthy astronauts will lose as much bone on a 90-day international Space Station mission as a typical aging person loses over ten years.

- What will we learn about osteoporosis in this environment?

- What will we learn about the maintenance of bone and muscle mass?

How many of our elderly could be saved from bone fractures by NASA's research on the balance system, on muscle atrophy, on blood pressure responses, and on bone demineralization?

Space flight produces major changes in the body's fluid balance system. Our work in space may lead to important new insights into mechanisms of hypotension and advances in treatments.

NASA has 18 active memoranda of agreement with the NIH. It's not surprising that the National Institute on Aging (NIA); the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS); and the National Heart, Lung, and Blood Institute, the National Institute for Child Health and Human Development (bioreactor) are among our partners at NIH.

Human-Machine Interface

Future possibilities --

The technologies NASA explores and develops could allow thousands of physically challenged people to become more independent. Robotic technology for exploration could become robotic technology for rehabilitation.

But advances in the human-machine interface will do more than enhance our physical capabilities. We have only begun to scratch the surface of the capabilities of computers to help us integrate data, to see and understand patterns -- in other words, to think.

Examples of current benefits --

• Neuroscience researchers at NASA's Ames Research Center are leading the way to creating virtual environments where humans interact with data. This is already leading to important discoveries. We've learned that:

-- Balance organs are organized as simple representations of the brain.

-- Sites of communication between cells (neurons) change in altered environments.

• These findings make balance organs a new model for studying how neuronal systems process information and learn.

• Other scientists are using the Ames systems to:

-- analyze the effects of toxic agents on developing organs

-- visualize neurochemical systems in the developing and adult brain

-- understand metabolic mapping of the brain

-- study how the brain learns by literally observing the changes in neurons during the learning process

Advanced Life Support

Future possibilities --

• NASA is on threshold of deploying devises that combine arrays of inexpensive polymers. The polymers respond to chemical contaminates when electrical currents are passed through the polymers.

They're connected by artificial neural nets that can identify the pattern unique to a specific chemical compound, and can remember that unique signal.

In principle, we are building an artificial dog's nose with the capacity to recognize, and in

principle to quantitate, chemicals. This stunning achievement will find applications everywhere -- from monitoring air quality to detecting explosives hidden in luggage.

I challenge the audience here today to start thinking about how you can apply this technology to improve the practice of medicine.

Examples of current benefits --

• Towns in Alaska are already using systems developed by NASA to purify water and dispose of waste in an environment where permafrost makes this difficult.

NASA's Exhibits and Wrap-up:

• NASA and the medical community have the makings of an incredible partnership.

• We want to make life better for the ill and the suffering, and we do that.

• We want to help develop new tools that help you better diagnose and treat your patients, and we do that.

• We have a lot to offer the medical community.

-- Microgravity gives us a unique laboratory.

-- Exploration requires a multi-disciplinary approach. We draw together teams of experts from disciplines that might not otherwise interact, integrating technological inputs and applying findings in a relatively short time frame.

-- Brilliant scientists and engineers at NASA.

- Find out about what we do.

-- Visit our exhibits in the Renaissance Hotel's Salon West A.

-- Search our databases to find out which NASA technologies have already become commercially available.

-- Take a look at the displays of emerging medical technologies.

- NASA's breakthroughs in science and technologies are driven by one thing. We

explore. We discover. We seek to uncover the mysteries of the universe.

- And along the way, we benefit the people here on Earth.

IV. ENDING

I started out my talk with a story about the Bell Atlantic employee who came to my door.

He was amazed at what NASA was doing. He watched us press the edge of the envelope, and he knew we were doing it for his children. For their quality of life, health care, competitiveness. For their intellectual and spiritual nourishment.

We'll keep pressing that edge -- keep reaching and risking and daring.

Decades from now, who knows what an unsuspecting Bell Atlantic employee may see if she knocks on a NASA Administrator's door.

Perhaps they'll sit in front of a screen and watch a picture slowly come into focus of a blue

planet with clouds. Or see the first human emerge from a spacecraft on Mars and set a firm boot down in the red dust.

Perhaps they, and the rest of the world, will see something that changes history, changes what it means to be human. Perhaps they'll see something that suddenly, and forever, changes everything.

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National Aeronautics and Space Administration

I. VISION

Intro:

The role of physicians has changed dramatically in the last decade or two. You don't just set a broken leg. Or deliver a child. Or perform a surgical procedure.

You deal with the social implications of a situation, like a contagious disease. You deal with cost issues -- whether the price of a test or procedure is justified. You deal with gender issues -- whether a study using men is applicable to women.

You deal with families and social workers and religious leaders and policy makers.

So you don't just do one thing. You don't look at one symptom or one set of symptoms in

isolation. You look at a much bigger picture. You treat the whole patient.

There's a parallel here with what NASA is going through. Your role is changing and expanding. It's becoming more complex, in a way. So is ours.

It used to be that we did one thing. We went to the Moon -- our job was to beat the Russians and prove our technical superiority.

Not any more. Today's demands are very different, and far more complex. NASA, like you, is called upon to do much more than one thing.

The end of the Cold War, a new era of budget constraints, the emergence of a global economy, a crisis in education, and many other factors mean that NASA must do much more. We have to look to the needs of America in a new, much broader way.

-- We must be cost-efficient.

-- We must use what we do in space to better life here on Earth -- to give taxpayers the best possible return on their investment.

-- We must boost U.S.-competitiveness.
-- we must rewrite physics & astronomy textbook from our research
-- We must inspire America's children in the areas of science and technology, which will be increasingly important to their future.

We must treat the whole patient, and meet a wider range of America's needs.

we must be Americus window on the future. Not just rockets belching fire

Speech Text:

biotech
biomed
robotics
expert decision making
advanced materials
advanced info systems

- Galileo
- CNN
- Geoff Marcy
- Hubble -- deep field galaxy, planet, star factory.

Things to Come:

- We just launched NEAR (2/15) -- kicked off over a dozen planetary exploration missions planned for the near future.

Remote Sensing:

- Hubble 2/97

  -- UV spectrometer

-- NEAR-IR imaging spectrometer

- Ground telescopes to detect more planets

- Study Earth environment

- We're opening the space frontier

- Findings strike a chord -- touch the human spirit (not only intellect).

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  -- Future for children

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WHAT AN EXCITING TIME TO BE ALIVE

- Others had same dream
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Decades ahead in our planetary exploration -- UNIFYING VISION

Understand -- Enrich -- Excite

- See planets light years away
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- Walk on bodies out of Earth orbit

<u>Exploration and Search for Origins and Sustenance of Life</u>:

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6) Attempt to determine some of the factors controlling the origin and fate of the universe, our solar system

7) Benefit people in America and on planet from richness of findings and technology utilized

-- Apollo era gone -- budget going down. 21st Century thinking in.

Let me turn, now, to our own solar system:

<u>Four Phases of Planetary Exploration</u>

1) Robotic Precursors

2) Initial Human Exploration

3) Robust Human Exploration

4) Sustained Human Presence

- Telescopic Observations
- Flyby (Mariner II to Venus)
- Orbit (Lunar/Mariner)
- Land (Surveyor/Viking)
- Rove (ground/air)
- Bring back samples (or in situ labs)
- People on surface

Threshold determined 01--02--03

- Potential benefit/cost -- scientific, economic

Output:

Scientific benefit examples:

1) Present or past forms of life

2) How planet structured, how evolved, implications to Earth's evolution or general theory

3) Unravel bodies' climatic/environmental history, better understand climatic/environmental models, better understand Earth

Economic benefit examples:

1) Finding resources to live off the land

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3) Environmental factors conducive to manufacture of high value products

Input

- Cost

  -- launch/cruise

  -- On body infrastructure

Rationally weigh

1) Government investment in science return or enabling space infrastructure (real potential) -- (science cost share)

2) Private investment in commerce

Search for life is most compelling (others just as interesting)

- Could there be blue green balls? Blue purple balls?

Chlorophyll -- rhodopsin
photosynthesis

Is life the same?

II. MEDICAL CHALLENGES TO CARRYING OUT THIS VISION

Space Station era
1997 - 2012

In General:

- We must address a broad array of scientific, technical, and medical challenges.

way they live now, filled with new capabilities and new dreams.

They look to NASA, too. They look to us to make their lives and their children's lives better -- from new industries and jobs to a stronger economy to revolutionary health care.

And they look to us, like they look to you, for hope. Because NASA reflects something all of you are intimate with -- the ferocious will and unshakable courage of the human spirit.

Thank you.

AMA
March 11, 1996

INTRO (Dr. Seward)

La Serrena 4m / 8m { • sunset • no pollution •

- 1987 Super Nova in Magellenic cloud
- substance of life generated in death
- understanding life cycle on grand scale

galaxies
solar systems
stars
planets

(Bell Atlantic)

- ~~DO~~
- Answering basic questions

(1) where did galaxies, stars, & planetary bodies come from and how did they evolve & and interact?

(2) Are there other places that had an enviornment, have an environment or might have an enviornments hospitable to life (of any form) or for human commerce

(3) Is life of any form unique to earth?

These are fundamental questions that deal with

- hopes & dreams of humans
- search for understanding & meaning of life
- intellectual nourishment necessary to fuel future endeavours
    - laws of physics on generation of matter & transformation of energy
    - understanding the evolution of life
    - rewrite physics, biology & chemistry textbooks
- search for resources and new technologies to make life richer on this planet
  industries of 21 century robots, computer aided / microchips sw elect.
- better understand the forces of nature on our own planet
    - long term climate prediction
    - long term warning of natural disaster: drought, rise in sea level, [illegible] induced pollutants.

NASA is about hopes & dreams

Bell Atlantic Technician

NASA looks at a broader picture

But in privacy of your office

you are about hopes & dreams

- bleak future
- people come to you for hope
- you are their connection to future
- ~~mountaintop experience~~

- NASA is Americas connection to future

hopes & dreams of nation

opportunity
understanding
inspiration
connection with future

Hubble planets, [faint] galaxies, digital [images]!
(written above "planets": here [illegible])

Near 2 weeks ago Eros

Galileo this June - Europa

Mars this fall

[Lichens] next summer

deep space 1

deep space 2
stardust

Tech
knowledge
internet.

9 missions
start 1998-2000
< Galileo

Armada small potent spacecraft
to explore
- our solar system
- other solar systems
- our own planet

Space station later
Opening Space Frontier

people think of NASA think of

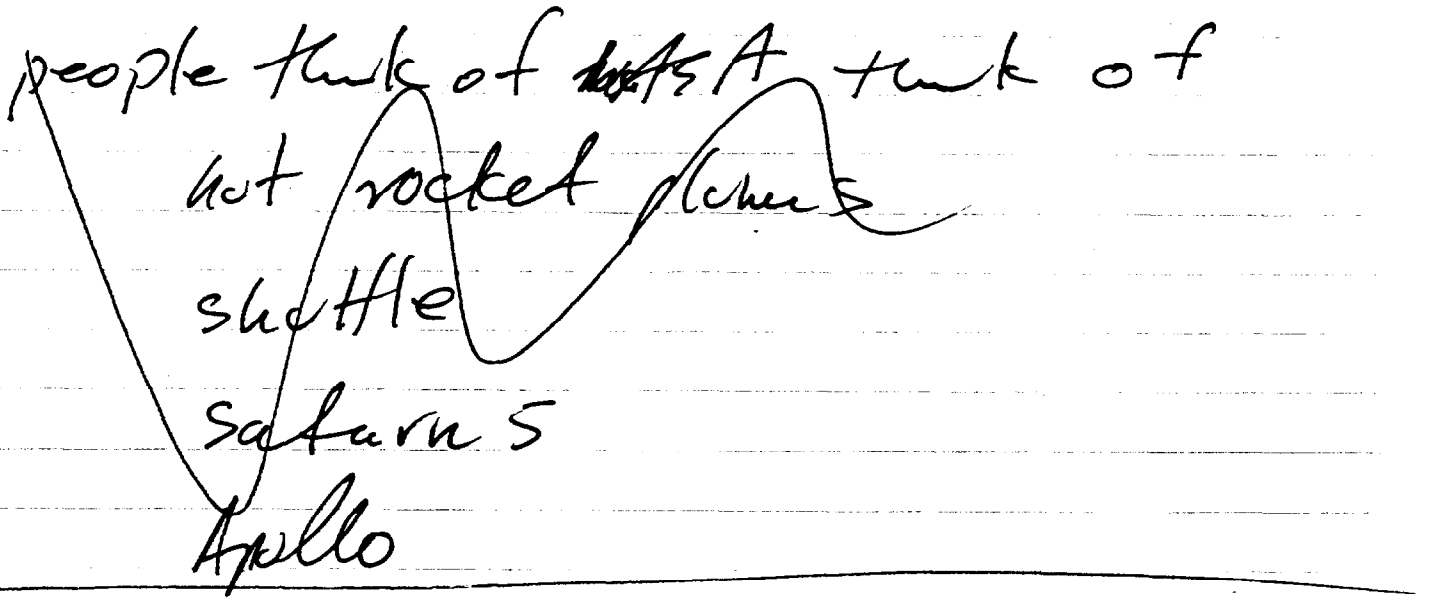
rockets

shuttle

saturn

Apollo

Much more.



one track

NASA is more than that

biotech	changes disease designer drugs in eg.
biomed	tissue culturing ~~artificial smell, sight, motion~~ total immersion simulation of aging effects
~~information~~	vector borne disease personal cooling
communications	telemedicine
international systems	total immersion multimedia Virtual institutes & laboratories
electronics	artificial smell, sight, hearing
computers	speeds & capabilities beyond belief
simulation	biological & physics based models built up from molecules and or/ universes
exploration	south pole south america clouds deserts undersea on surface of Mars, Europa moon, asteroid!

as far as aided eye can see

Opening space further

Findings strike chord - touch
human spirit make us alive

USA today weekend edition
broadcast

origins
future of children

Not just day to day

why are we here
How do it relate
where are we going
what are possibilites

More than food & shelter

what an exciting time to be alive

others had same dreams

we have tools

Understand Enrich Excite

unmanned missions / see planets lightyears away
Analyze bodies nearby (earth)
people robots / walk on planetary bodies

Robotic Precursors
Initial Human Exploration
Robust Human Exploration
Sustained Presence
Hierarchy of Measures
Telescope grids — space
Flyby
Orbit
Land
Rover
Bring back samples
People on surface
cost / benefit

step

Scientific

(1) Present/past forms of life
early 500 M years ago 10 MY
single cell → ~~complex~~ life.

2) How planet structural, evolved
implications to earths evolution
or general physical theories

3) unravel bodies climatic/
environmental history to
better understand earth
venus
Mars

Economic

(1) Finding resources to live off land

(2) Natural resources

(3) Environment conducive to high
value mfg

cut cost
regenerative life support

Sounds for life most appealing

Blue green bells
Blue purple bells
Is life sure

Spike Stark

- We must integrate progress in a broad range of disciplines.

- We will create systems of unprecedented complexity. Yet, these systems will be absolutely reliable -- self-diagnosing and self-repairing.

- We will need to combine operational simplicity with a remarkable level of inherent complexity.

Specific Medical Challenges:

1) Environmental Quality in Space

- Need life support systems for exploration that are significantly less massive and require only minimal resupply of consumables like water, air, and food.

- Biological and physical/chemical life support systems must be harnessed together. (Plant systems genetically selected to maximize oxygen and food production may be combined with microbial systems that can purify water. Special chemical filters may remove or regulate the microbes and remove toxins from the air. New material will be developed to prevent the

formation of biofilms on surface in the spacecraft.)

2) Radiation Environment

• In space, beyond the protection of the Earth's magnetic field, we face not only gamma rays, protons and neutrons but also large plasma particles consisting of atomic nuclei like iron -- so-called cosmic rays.

• We must learn more about the effects of space radiation, and how to protect space crews (especially from cosmic rays).

• We'll need advanced integrated spacecraft immune from cosmic rays and radiation. We'll need new types of radiation shielding materials -- may include new carbonaceous and hydrogenated organics.

• Need new medical techniques to select crews and protect them against space radiation. We may need to identify genetic markers or other indicators that will allow us to identify individuals at low risk for eventually developing cancer.

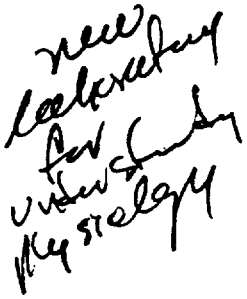
• How is the biological damage caused by radiation repaired in microgravity? Can

medication prevent damage or improve and hasten repair?

3) Counteracting the Negative Effects of Low Gravity on the Human Body

• Travel in space exposes life to a gravity environment that's unique in the 4-billion-year history of life on Earth. This presents us with remarkable opportunities for medical research in space. It also presents us with medical challenges for maintaining crew health on long journeys.

• Long exposure to microgravity influences virtually every system in the body. We will need to identify and control the negative effects of long-term space flight.



- Bone loss
- Muscle atrophy
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adapt, developing new connections (synapses) with other nerve cells .

- What are the implications for long-term adaptation?

- There is evidence that the body retains these adaptations for some time after returning to Earth. Perhaps we can harness these phenomena to encourage recovery in conditions where nerve cells in the brain or spinal cord are injured.

4) Providing Health Care

- Must be able to support the health care needs of a very remote crew.

- The communication time to Earth at the speed of light will take at least 20 to 50 minutes for long journeys. Need telemedicine and informational tools that can assist in medical decision-making while helping the medical crew retain their medical and surgical skills.

- Need totally new concepts for medical care on very long space flights: nano-technology, chemical surgery, methods for selecting and inducing resistance to illness.

5) Dealing with Psychological Factors of Long-Term Isolation in Space

Our space crews will be farther from home than anyone has ever been before. They'll be:

- away from their families and friends
- confined to a small space for long periods of time
- surrounded by an immense and hostile environment
- unable to hold a normal conversation with anyone not on their spaceship.

\ 20 -50 minute delays

Challenges:

- How do we keep a crew psychologically healthy under these circumstances?

- How will the crew adapt, how will they function as a team?

- How do we prepare the crew to respond to emergencies in space?

- How do we prepare them to deal with emergencies at home?

We'll need to develop novel approaches to communications and information transfer.

6) Integrating Humans, Robots, and Computers into Efficient and Self-Sufficient Systems in Space

• **Robots** will be the human surrogate and assistant. They will see, hear, touch, smell, speak, think, learn, and perform controlled mechanical operations.

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Genetic algorithms will provide stable state changes in complex systems. Those processes and algorithms must be adapted into new tool sets.

III. MEDICAL BENEFITS ON EARTH OF PURSUING NASA'S VISION IN SPACE

What we do in space could have tremendous application on Earth. I'm just going to mention a few possibilities and actual benefits in the areas of:

- Health Care
- Biomedical Research
- Human-Machine Interface, and
- Advanced Life Support

Health Care

Future possibilities --

• Imagine the implications of developing systems and technologies to provide health-care across distances of millions of miles!

-- Chemical surgery techniques that can heal without scalpels or incisions

-- Micro-machines in the bodies of our crews to monitor or treat problems

-- Artificial antibodies to deliver "nano-machines" directly to the site of a problem

• What could screening techniques for astronauts mean on Earth? Could our multi-disciplinary approach to this lead to early detection and prevention of disease?

Examples of current benefits --

• Already, "telemedicine"--~~pioneered in the Apollo days~~-- promises to vastly improve medical care. It's been used during natural disasters and to serve the needs of remote populations in the southwestern United States.

Internet technology promises to greatly expand this capability.

- Tiny sensors that measure the pH of body fluids were developed for use in space research. Now, they're being modified by pediatric surgeons from the University of California at San Francisco and NASA biomedical engineers to monitor the post-operative health of unborn patients who were operated on to correct congenital anomalies, such as the lack of a diaphragm.

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Healthy astronauts will lose as much bone on a 90-day international Space Station mission as a typical aging person loses over ten years.

- What will we learn about osteoporosis in this environment?

- What will we learn about the maintenance of bone and muscle mass?

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Space flight produces major changes in the body's fluid balance system. Our work in space may lead to important new insights into mechanisms of hypotension and advances in treatments.

NASA has 18 active memoranda of agreement with the NIH. It's not surprising that the National Institute on Aging (NIA); the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS); and the National Heart, Lung, and Blood Institute, the National Institute for Child Health and Human Development (bioreactor) are among our partners at NIH.

<u>Human-Machine Interface</u>

Future possibilities --

The technologies NASA explores and develops could allow thousands of physically challenged people to become more independent. Robotic technology for exploration could become robotic technology for rehabilitation.

But advances in the human-machine interface will do more than enhance our physical capabilities. We have only begun to scratch the surface of the capabilities of computers to help us integrate data, to see and understand patterns -- in other words, to think.

Examples of current benefits --

• Neuroscience researchers at NASA's Ames Research Center are leading the way to creating virtual environments where humans interact with data. This is already leading to important discoveries. We've learned that:

-- Balance organs are organized as simple representations of the brain.

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They're connected by artificial neural nets that can identify the pattern unique to a specific chemical compound, and can remember that unique signal.

In principle, we are building an artificial dog's nose with the capacity to recognize, and in principle to quantitate, chemicals. This stunning achievement will find applications everywhere -- from monitoring air quality to detecting explosives hidden in luggage. Fly ??

I challenge the audience here today to start thinking about how you can apply this technology to improve the practice of medicine.

Examples of current benefits --

• Towns in Alaska are already using systems developed by NASA to purify water and dispose of waste in an environment where permafrost makes this difficult. digital mammography ~~resolution~~ tissue culture protein crystal growth

NASA's Exhibits and Wrap-up: ventricular assist vector bovine decrease

• NASA and the medical community have the makings of an incredible partnership.

• We want to make life better for the ill and the suffering, and we do that.

• We want to help develop new tools that help you better diagnose and treat your patients, and we do that.

• We have a lot to offer the medical community.

-- Microgravity gives us a unique laboratory.

-- Exploration requires a multi-disciplinary approach. We draw together teams of experts from disciplines that might not otherwise interact, integrating technological inputs and applying findings in a relatively short time frame.

-- Brilliant scientists and engineers at NASA.

• Find out about what we do.

-- Visit our exhibits in the Renaissance Hotel's Salon West A.

-- Search our databases to find out which NASA technologies have already become commercially available.

-- Take a look at the displays of emerging medical technologies.

• NASA's breakthroughs in science and technologies are driven by one thing. We explore. We discover. We seek to uncover the mysteries of the universe.

• And along the way, we benefit the people here on Earth.

IV. ENDING

I started my talk by drawing some parallels between your expanding role in society, and NASA's.

Let me end with a last thought about that.

When I said that today, you treat the whole patient, I didn't just mean their whole body. I meant, in some sense, their whole self.

Your patients look to you for many things beyond your medical expertise. They look to you for hope. They may even look to you for a new future -- a changed life, very different from the

Patients look to you for many things beyond medical expertise

new future

changed life different from what they live now

filled with new capabilities & new dreams

They look to NASA too

make their lives & children's better

new industries & jobs

stoke economy

revolutionary health care

inspiration

~~Look to you &~~

look to you & us for hope

Because NASA reflects
something all of you associate
with

the ferocious will and
unshakable courage
of human spirit.

AMA
March 11, 1996

INTRO (Dr. Seward)

Lee Co... ra 4m / 8m { • sunset • no pollution •

NOTES USED

per Nova in Magellenic cloud

...ce of life generated in death

- understanding life cycle on grand scale
  - galaxies
  - solar systems
  - stars
  - planets

~~• DO~~ (Bell Atlantic)

- Answering basic questions
  (1) where did galaxies, stars, & planetary bodies come from and how did they evolve & and interact?

  (2) Are there other places that had an enviornment, have an environment or might have an enviornment hospitable to life (of any form) or for human commerce

(3) Is life of any form unique to earth?

These are fundamental questions that deal with

- hopes & dreams of humans
- search for understanding & meaning of life
- intellectual nourishment necessary to fuel future endeavours
    - laws of physics on generation of matter & transformation of energy
    - understanding the evolution of life
    - rewrite physics, biology & chemistry textbooks
- search for resources and new technologies to make life richer on this planet, interactions of AI with robots, augmented reality / microchips in electronics
- better understand the forces of nature on our own planet
    - long term climate prediction
    - long term warning of natural disasters drought
    - control of human induced pollutants. rise in sea level

NASA is about hopes & dreams

Bell Atlantic Technician

NASA looks at a broader picture

But in privacy of your office

you are about hopes & dreams

- bleak future
- people come to you for hope
- you are their connection to future
- ~~mountaintop experience~~

- NASA is Americas connection to future

hopes & dreams of nation

opportunity
understanding
inspiration
connection with future

Hubble planets, [here/there above] faint galaxies, digital [illegible]

Near 2 weeks ago Eros

Galileo this June - Europa

Mars this fall

[illegible] next summer

deep space 1

deep space 2
stardust

Tech
knowledge
internet.

9 missions 199[illegible]-2000
start
< Galileo

Armada small potent spacecraft
to explore

- our solar system
- other solar systems
- our own planet

Space station later

Opening Space Frontier

people think of NASA think of
rockets
shuttle
saturn
Apollo

Much More

people think of ~~NASA~~ think of

hot rocket planes

shuttle

Saturn 5

Apollo

One track

NASA is more than that

biotech	changes disease designer drugs in eg.
biomed	tissue culturing ~~total immersion artificial smell, sight, mot~~ simulation of aging effects
~~information~~	vector borne disease
communications	personal cooling telemedicine
interactive systems	total immersion multimedia Virtual institutes & laboratories
electronics	artificial smell, sight, hearing
computers	speeds & capabilities beyond belief
simulation	biological & physics based models built up from molecules and or/ universes
exploration	south pole south america undersea on surface of mars, europa moon, asteroid !

clouds deserts

as far as aided eye can see

Opening space further

Findings strike chord - touch
human spirit make us alive

USA today weekend edition
broadcast

origins
future of children

Not just day to day

why are we here
How do it relate
where are we going
what are possibilites

More than food & shelter

what an exciting time to be alive

others had same dreams

we have tools

Understand Enrich Excite

unify vis

people robots

see planets lightyears away
Analyze bodies nearby (earth)
walk on planetary bodies

Robotic Precursors

Initial Human Exploration

Robust Human Exploration

Sustained Presence

Hierarchy of Missions

Telescope grand — space
Flyby
orbit
land
Rove
Bring back samples
People on surface

cost / benefit

step

Scientific

(1) Present/past forms of life
earth 500 M years ago 10 My
style cell → ~~eukaryotic~~ life

2) How plant structural, evolved
implications to earths' evolution
or general physical theories

3) unravel paleo climatic/
environmental history to
better understand earth
views
Mars

Economic

(1) Funding resources to live off land

(2) Natural resources

(3) Environment conducive to high
value mfg

At cost
regenerative life support

Search for life most expelling

Blue green balls
Blue purple balls
In life sure

Spike Milligan

American Medical Association

March 11, 1996

Remarks Prepared for Delivery By:

Daniel S. Goldin
Administrator
National Aeronautics and Space Administration

I. VISION

Intro:

The role of physicians has changed dramatically in the last decade or two. You don't just set a broken leg. Or deliver a child. Or perform a surgical procedure.

You deal with the social implications of a situation, like a contagious disease. You deal with cost issues -- whether the price of a test or procedure is justified. You deal with gender issues -- whether a study using men is applicable to women.

You deal with families and social workers and religious leaders and policy makers.

So you don't just do one thing. You don't look at one symptom or one set of symptoms in

isolation. You look at a much bigger picture. You treat the whole patient.

There's a parallel here with what NASA is going through. Your role is changing and expanding. It's becoming more complex, in a way. So is ours.

It used to be that we did one thing. We went to the Moon -- our job was to beat the Russians and prove our technical superiority.

Not any more. Today's demands are very different, and far more complex. NASA, like you, is called upon to do much more than one thing.

The end of the Cold War, a new era of budget constraints, the emergence of a global economy, a crisis in education, and many other factors mean that NASA must do much more. We have to look to the needs of America in a new, much broader way.

-- We must be cost-efficient.

-- We must use what we do in space to better life here on Earth -- to give taxpayers the best possible return on their investment.

-- We must boost U.S.-competitiveness.

-- We must inspire America's children in the areas of science and technology, which will be increasingly important to their future.

We must treat the whole patient, and meet a wider range of America's needs.

Speech Text:

- Galileo
- CNN
- Geoff Marcy
- Hubble -- deep field galaxy, planet, star factory.

Things to Come

- We just launched NEAR (2/15) -- kicked off over a dozen planetary exploration missions planned for the near future.

Remote Sensing

- Hubble 2/97

    -- UV spectrometer

-- NEAR-IR imaging spectrometer

- Ground telescopes to detect more planets

- Study Earth environment

- We're opening the space frontier

- Findings strike a chord -- touch the human spirit (not only intellect).

- Touch need to explore

  -- Origins
  -- Future for children

- Don't worry day to day

  -- Why are we here?
  -- How do I relate?
  -- Where are we going?
  -- What are the possibilities?

- More than food and shelter

  -- Understand order
  -- Enriching life
  -- Better understand their God

- Drives me

-- Pinch to see if real
-- Privilege bestowed by President
each day, until he decides not to.
-- That's been known to happen

WHAT AN EXCITING TIME TO BE ALIVE

- Others had same dream
- We have the tools
- It is the dawn of a new era!

Decades ahead in our planetary exploration -- UNIFYING VISION

Understand -- Enrich -- Excite

- See planets light years away
- Analyze bodies near by
- Walk on bodies out of Earth orbit

<u>Exploration and Search for Origins and Sustenance of Life</u>:

Three fundamental interconnected multidisciplinary questions --

1) Where did galaxies, stars and planetary bodies come from and how did they evolve?

2) Are there other places that had an "environment," have an environment, or might have an environment hospitable to life and/or commerce?

3) Is life of any form unique to Earth?

SUSTAINED PRESENCE

To attempt to answer these questions, we could:

1) Survey space to search for and analyze earliest forms of galaxy

2) Search for and analyze stars and planetary systems in process of forming

3) Search for and analyze extrasolar planetary systems in our "neighborhood"

4) Search for and analyze planetary bodies that were, are, or could be habitable and/or could have resources of economic interest

5) Search for resources and/or signs of life (including alternative forms) in our own solar system -- places we have yet to go to and "appropriately" explore

6) Attempt to determine some of the factors controlling the origin and fate of the universe, our solar system

7) Benefit people in America and on planet from richness of findings and technology utilized

-- Apollo era gone -- budget going down. 21st Century thinking in.

Let me turn, now, to our own solar system:

Four Phases of Planetary Exploration

1) Robotic Precursors

2) Initial Human Exploration

3) Robust Human Exploration

4) Sustained Human Presence

- Telescopic Observations
- Flyby (Mariner II to Venus)
- Orbit (Lunar/Mariner)
- Land (Surveyor/Viking)
- Rove (ground/air)
- Bring back samples (or in situ labs)
- People on surface

Threshold determined 01--02--03

- Potential benefit/cost -- scientific, economic

Output:

Scientific benefit examples :

1) Present or past forms of life

2) How planet structured, how evolved, implications to Earth's evolution or general theory

3) Unravel bodies' climatic/environmental history, better understand climatic/environmental models, better understand Earth

Economic benefit examples:

1) Finding resources to live off the land

2) "Natural resources" of economic value

3) Environmental factors conducive to manufacture of high value products

Input

- Cost

  -- launch/cruise

  -- On body infrastructure

Rationally weigh

1) Government investment in science return or enabling space infrastructure (real potential) -- (science cost share)

2) Private investment in commerce

Search for life is most compelling (others just as interesting)

- Could there be blue green balls? Blue purple balls?

Chlorophyll -- rhodopsin
photosynthesis

Is life the same?

II. MEDICAL CHALLENGES TO CARRYING OUT THIS VISION

In General:

- We must address a broad array of scientific, technical, and medical challenges.

- We must integrate progress in a broad range of disciplines.

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Let me end with a last thought about that.

When I said that today, you treat the whole patient, I didn't just mean their whole body. I meant, in some sense, their whole self.

Your patients look to you for many things beyond your medical expertise. They look to you for hope. They may even look to you for a new future -- a changed life, very different from the

way they live now, filled with new capabilities and new dreams.

They look to NASA, too. They look to us to make their lives and their children's lives better -- from new industries and jobs to a stronger economy to revolutionary health care.

And they look to us, like they look to you, for hope. Because NASA reflects something all of you are intimate with -- the ferocious will and unshakable courage of the human spirit.

Thank you.